FINAL REPORT

Contract Number
NAS8-39401

Prepared by

Uwohali, Incorporated
4950 Research Drive
Huntsville, AL 35805

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1.0 INTRODUCTION

The purpose of this Final Report is to document and summarize the results of the effort expended under contract number NAS8-39401. This contract began on June 23, 1992 and terminates on June 23, 1995.

The organization and presentation of the data in this report follows the description of the engineering activities defined in the Scope of Work, Attachment J-1, of this contract. In this Attachment, all engineering requirements were organized into two tasks:

1. Ground Test System (GTS) Sustaining Engineering
2. Enhancements to the GTS

The conclusion of the activities associated with these two tasks was to provide a system to support "real time" data collection, display, recording and analysis for the Astro 2 mission.

1.1 Task 1

Task 1, GTS Sustaining Engineering, included those activities associated with providing GTS support to the Government during utilization of the system. This support consisted of analyzing system anomalies and providing software corrections for any design and implementation errors. Support under this Task also included the investigation of product improvements to facilitate ease of system utilization or to enhance existing capabilities provided.

1.2 Task 2

Within the scope of this Task, the contractor was required to design, code, test, and demonstrate the following enhancements to the GTS:

1. Activation and deactivation of individual measurements being Exception Monitored
2. Edit capability for strip chart measurements
3. Provision of printout flags for Exception Monitor begin/end
4. Strip chart recorder release during loss of signal
5. Addition of data type "E" for display
6. Major frame dump in hex format
7. Snapshot of Event Monitor based on measurement status
8. Ethernet interface utilizing the POCC Peripheral Processor Protocol

Also, as required, the contractor will provide updates to existing GTS documentation.

2.0 CONTRACT SUMMARY

2.1 Task 1

2.1.1 GTS Anomalies

Contract documentation requirements defined in the Scope of Work specified that all GTS problems discovered and corrected were to be summarized in the monthly status report. A

description of each system anomaly analyzed, corrected, and tested can be found in the monthly status reports generated over the life cycle of this contract.

2.1.2 Investigation Of GTS Improvements

The following presents a discussion of the product improvements considered and the final disposition of each option analyzed.

2.1.2.1 Data Logging Over Ethernet

As a replacement for the storage of telemetry data on magnetic tape, the possibility of logging telemetry data to an Ethernet based "Archival/Retrieval Storage System (ARSS) was investigated. ARSS requirements and design specifications were analyzed and discussed with NASA engineering personnel. As a result of these discussions and man power estimates, it was decided to pursue this option to the point where proof of concept could be determined.

Within the constraints of available resources, "real-time" data logging to an Ethernet based optical storage system was accomplished and considered to be a desirable replacement for magnetic tape recording.

2.1.2.2 Processing Of Multiple Data Streams

The GTS as designed is capable of acquiring and processing a single telemetry stream. It is the responsibility of the GTS System Manager to select which one of the Spacelab HRM channels to process.

The capability to simultaneously acquire telemetry data from multiple channels was analyzed, and implementation ramifications were presented and discussed with NASA engineers. Although this improvement was considered to be highly desirable, the time and cost required to implement this option was considered prohibitive by NASA. The purchase and integration of new decommutation hardware was required as well as additional computer hardware and software licenses. Furthermore, man power cost estimates required to design, implement, test, and document this option were not within the available hours of this contract.

2.1.2.3 Upgrade of Decommutation/PSIM Hardware

The decommutation of telemetry data and the "play back" of a recorded telemetry stream are currently accomplished using custom fabricated wire wrapped boards designed during the late 1980s.

The possibility of replacing these two modules with commercial off-the-shelf hardware was analyzed. Again, although a commercial product did exist that would replace these two boards with a single module and considerably enhance the operational capability of the GTS, cost considerations prohibited its implementation.

2.1.2.4 Near Real Time (NRT) Data Processing

The capability to present NRT data to a user when the GTS is in "Real Time" mode was explored. NRT processing and associated user interfaces were implemented to the stage where proof of concept was attained and an assurance that this function could be provided with existing GTS computer resources.

2.1.2.5 Application Task Development

Approximately one year before the scheduled beginning of the Astro 2 mission, users of the GTS requested the development of three additional application tasks. All three tasks were designed, coded, and integrated into the baseline GTS for use during the Astro 2 flight.

2.1.2.5.1 IMCVALID

The first task implemented, "imcvalid," displays software error status information for both the Astro Star Tracker (AST) and the Dedicated Experiment Processor (DEP). A two digit error code and associated ASCII text message are displayed for each possible error condition. A maximum of four errors of each type can be presented simultaneously. If more than four errors occur, the display area for each type will scroll. Figure 2-1 presents the format for the display of this data.

2.1.2.5.2 DRIRU

The second task developed specifically for the Astro 2 mission, "driru," displays three columns of gyro data for each of the six on board gyros, see Figure 2-2. The first column, "GYRO INCREMENT FIRST SAMPLE," represents measurement data for each gyro from minor frame 0 of each major frame. The next column, "GYRO INCREMENT SUM OF 50 SAMPLES," represents the algebraic sum of 50 samples for each axis. The final or third column, "GYRO INCREMENT AVERAGE OF 50 SAMPLES," displays the calculated average gyro value for each axis.

2.1.2.5.3 STARPLOT

The final task implemented, "starplot," displays a graphical representation of the star field currently being tracked as well as engineering measurements for:

1. Star brightness and magnitude
2. Star position within the field of view in pixels and arc minutes
3. Integration interval and integration time
4. Operational mode
5. Error status information in ASCII and numeric format

Figure 2-3 presents the design format of the data displayed by the "starplot" task.

GMT:343:19:19:36 STATUS:HRM Running: ASPS-T DB:1000403A TEST: EM:NO

Gts Monitor Help Display Recorder Status Last Freeze

GT7100 - DEP AND AST ERROR MESSAGES

ERROR CODES DEP ERROR MESSAGES

00 NO ERROR

!! !!

!! !!

!! !!

AST ERROR MESSAGES

00 NO ERROR

!! !!

!! !!

!! !!

Figure 2-1

bs1873a

GMT:343:19:19:36 STATUS:HRM Running: ASPS-T DB:1000403A TEST: EM:NO

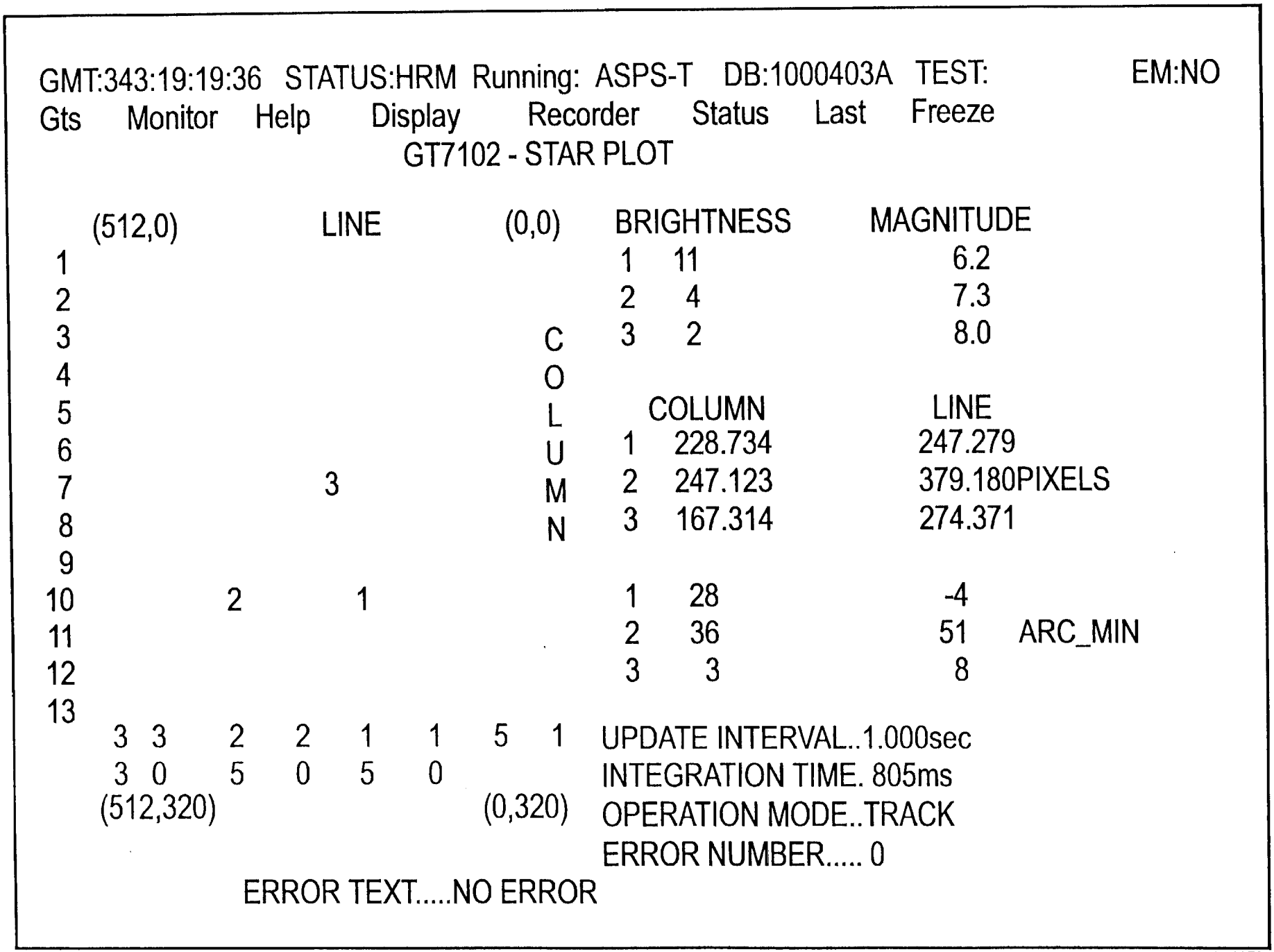
Gts Monitor Help Display Recorder Status Last Freeze

GT701 - DRIRU II

	GYRO INCREMENT FIRST SAMPLE (ARCSEC/S)	GYRO INCREMENT SUM OF 50 SAMPLES (ARCSEC/S)	GYRO INCREMENT AVERAGE OF 50 SAMPLES (ARCSEC/S)
AX..	0.007381	0.107642	0.002153
BX..	-0.010522	0.123613	0.002472
BY..	0.037749	-0.423123	-0.008462
CY..	0.040293	-0.437203	-0.008744
AZ..	0.039827	0.354626	0.007093
CZ..	0.046856	0.315232	0.006305

bs1873b

Figure 2-2



bs1873c

Figure 2-3

2.2 Task 2

2.2.1 GTS Enhancements

2.2.1.1 Activation/Deactivation Of Individual Measurements Being Exception Monitored

This enhancement was accomplished by adding two options to the "Monitor Pulldown" menu:

1. Activate Exception PID
2. Deactivate Exception PID

"Activate Exception PID" permits a user to activate an individual PID in an active Exception Monitor file. In response to this selection, a "dialog box" is displayed requesting the user to enter the name of one of the PIDs in the active Exception Monitor file. The PID name is legality checked against the list of valid PID names for this file: if the PID is valid, the monitoring status is changed to "active;" if the name is illegal, an error message is displayed for the user.

The design approach described above was also implemented for "Deactivate Exception PID."

This capability was demonstrated to NASA and used during the Astro 2 mission.

2.2.1.2 Edit Capability For Strip Chart Measurements

Design and code modifications to the Strip Chart editing function were required to implement this enhancement. NASA engineers agreed to reformat the Strip Chart editing display with channel numbers 1 through 8 and, as users, assign measurements to a channel to display that MSID next to the selected channel number.

This modification was demonstrated to NASA and used during the Astro 2 mission to generate Strip Chart files.

As a result of this modification, all Strip Chart files defined during the Astro 1 mission were modified to reflect the revised channel assignment procedure.

2.2.1.3 Provision Of Printout Flags For Exception Monitor Begin/End

This requirement to delineate the begin and end of hard copy output for Exception Monitor PIDs was satisfied by adding a "header" and "trailer" to the line printer output. Each time a user requests an Event Monitor printout, a " Begin Event Monitoring Printout For All PIDs" is printed before any MSID data. The hard copy output terminates with the "trailer" "End Event Monitoring Printout For All PIDs."

This annotation was used during the Astro 2 mission for Event Monitor printouts.

2.2.1.4 Strip Chart Recorder Release During Loss Of Signal

After review and discussion with NASA engineers, two design options were considered to be valid. The first option required the addition of a new "decom" board, see Section 2.1.2.3, and

was considered to be the most desirable option. The second option required the modification of existing GTS software executing under the pSOS operating system.

As discussed in Section 2.1.2.3 the addition of a new decom board was cost prohibitive; therefore, release from loss of signal was accomplished through the modification of Strip Chart software.

Modifications were implemented and this capability was used extensively during the Astro 2 mission.

2.2.1.5 Addition Of Data Type "E" For Display

The capability to display MSID data in exponential format (E) required the modification to both the display generation task and to the display formatting function. The display generation task was modified to include the exponential display format option for MSIDs whose engineering values could be displayed in this manner. The display formatting function was modified to present data in exponential format when this option was selected by the user.

Displays created for the Astro 2 mission presented data in exponential format.

2.2.1.6 Major Frame Dump In Hex Format

The ability to print a major frame in hexadecimal format was implemented by providing the user with a "Pulldown" menu option to "PRINT MAJOR FRAME."

When this option is selected, a major frame of telemetry data is formatted and scheduled for printing on the GTS hard copy device.

2.2.1.7 Snapshot Of Event Monitor Based On Measurement Status

The concept of a "trigger" PID was introduced into the GTS in order to schedule Event Monitor printout based on the value of a measurement.

The user option, "TRIGGER PID" was added to the Monitor "Pulldown" menu. In response to this request, a dialog box is opened prompting the user to enter the name of the PID to be used as the "trigger." During telemetry processing the "trigger" PID is automatically monitored; when its delta is exceeded, all PIDs in the currently active Event Monitor file and their related data are printed on the line printer.

2.2.1.8 Ethernet Interface Utilizing The POCC Peripheral Processor Protocol

This enhancement to the GTS was the first requirement implemented. The modifications to the GTS include:

1. Addition of ENP10 Ethernet hardware to the GTS baseline configuration
2. Development of ENP10 device driver for UNIX
3. Sysgening of UNIX kernel to include ENP10 device driver

4. Generation of ENP10 load module
5. Initialization of ENP10 module
6. Testing of read/write from application tasks over Ethernet using ENP10

Verification and demonstration of this capability to NASA was accomplished using the GTS "play back" mode and a "nutcracker." Ethernet packets were monitored and recorded using the "nutcracker." Data integrity was verified by comparing packet content against the GTS data file transferred.

2.2.2 Documentation Updates

Because of the extent of the modifications and enhancements made to the GTS under this contract, it was decided to completely rewrite and reissue both the "Ground Test System Operations Guide" and "Requirements For A Real-Time Ground Test Applications Support System (GTS)."

On February 1, 1994, the "Ground Test System Operations Guide" was published and released for distribution. This document subsequently served as the primary training document for those users who attended GTS training classes and who would be operating the GTS during the Astro 2 mission.

On December 15, 1994, the document entitled "Requirements For A Real-Time Ground Test Applications System (GTS)" was formally released for distribution.

3.0 RECOMMENDATIONS

The following recommendations are based on discussions with users of the GTS and observed system performance during implementation and testing. It is assumed for purposes of these recommendations that the primary role satisfied by the GTS has not changed.

3.1 Hardware Upgrade

All of the hardware components comprising the GTS are at least one generation behind current technology.

The CPU module, executing UNIX, is based on the Motorola 68030 processor. The CPU boards executing the "real-time" executives use the 68020 processor and are limited to 1 MB of memory. Both of these modules are no longer available in Motorola's pricing literature.

The "decom" and "PSIM" modules are custom wire wrap boards designed and fabricated during the late 1980s. These are one-of-a-kind boards and represent single point failures that would require dedicated resources to debug and repair.

Because of the design of the CPU and "decom" modules, the GTS is limited to a total of 16 MB of memory. This has proven to be a constant source of problems when considering any GTS enhancement.

The data logging devices, magnetic tapes, are at least eight years old and require constant adjustment and maintenance. Because they are primarily a mechanical device, they have become the limiting component in increasing system performance.

If the GTS is to be used in the future, NASA should consider upgrading as many of these modules as is economically feasible.

3.2 Software Upgrade

The commercial off-the-shelf software used by the GTS is as dated as the hardware listed above.

The "real-time" kernel, pSOS, was purchased in 1987 and is no longer available nor supported. This kernel and supporting components have been extensively upgraded and enhanced by the vendor.

The version of UNIX used by the GTS was purchased during the late 1980s and is no longer available. Numerous version releases of UNIX with enhanced capabilities have been issued by the vendor. Also, during the implementation of the GTS, UNIX problems were discovered that required "work arounds" in order to satisfy system level requirements.

If GTS hardware is updated, the commercial off-the-shelf supporting software must also be upgraded. These modifications to the baseline GTS configuration must be implemented in tandem if they implemented at all.

3.3 Telemetry Data Recording

The recording of telemetry data to magnetic tape has limited user appeal and restricts system performance. As discussed in section 2.1.2.1 of this report, a viable alternative to magnetic tape logging was proven under this contract. The logging of data over an Ethernet interface to an optical storage system provides orders of magnitude in increased performance and enhanced system versatility; i.e., reading/writing to an optical storage system can occur "simultaneously."

Of all the recommendations suggested, this enhancement is the most compelling. As noted earlier, this modification can be implemented with existing hardware and commercial off-the-shelf software.

3.4 Data Presentation

Data processed on the GTS can be displayed only in alphanumeric format; the capability to present engineering data in color and/or graphics does not exist.

The limitation of an alphanumeric-only display capability severely restricts the utility of the GTS as a general purpose test system. The display system is "slow," 9600 baud to the terminal, and difficult to view when monitoring a multitude of engineering values updating at least once a second.

The question as to whether the GTS should provide local graphic/color capability or interface to a "workstation" over Ethernet must be addressed. In any event, this feature has become a defacto standard.